

CLAIMS

What is claimed:

- 1 1. A method of transcoding a digital stream of compressed frames, the method
2 comprising the steps of:
3 (a) receiving a compressed video frame having content information and non-
4 content information included therein;
5 (b) determining the total compressed size of the frame (N_T);
6 (c) determining from at least the total compressed size of the frame the total
7 number of bits (N_S) to shave from the compressed frame;
8 (d) determining a plurality of statistics about a given portion of the frame;
9 (e) determining whether to requantize the given portion based at least in part upon
10 at least one of the statistics about the given portion;
11 (f) responsive to determining to requantize the given portion, requantizing the
12 levels of the given portion;
13 (g) determining whether to threshold the given portion based at least in part on the
14 at least one of the statistics about the given portion;
15 (h) responsive to determining to threshold the given portion, thresholding the
16 levels of the given portion; and
17 (i) transmitting the given portion.
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1 2. The method of claim 1, prior to step (d), further including the steps of:
2 (j) decompressing the video frame into a DCT-domain, wherein in the DCT-
3 domain blocks of pixel information are represented as blocks of levels;
4 (k) parsing the frame into a plurality of portions; and
5 prior to step (i), re-compressing the given portion, wherein the given transmitted
6 in step (i) is the re-compressed given portion.
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1 3. The method of claim 1, wherein the plurality of statistics about the given portion
2 include the compressed content size (S_{size}) of the given portion.
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1 4. The method of claim 1, wherein the plurality of statistics about the given portion
2 include the average of the quantization parameters used to quantize the levels of the given
3 portion.

1 5. The method of claim 1, wherein the plurality of statistics about the given portion
2 include the average of the runs in the given portion.

1 6. The method of claim 1, further including the steps of:
2 prior to the step (e), determining the initial compressed content size (S_{int}) of the
3 given portion;
4 prior to the step (e), determining a target number of bits to shave (N_{shave}) from
5 the given portion;
6 prior to the step (i), determining the final compressed content size (S_{fnl}) of the
7 given portion; and
8 calculating the reduction error (e) for the given portion, wherein the reduction
9 error is defined as the difference between the target number of bits to
10 shave and the difference between final and initial compressed content size,
11 $e = N_{\text{shave}} - (S_{\text{fnl}} - S_{\text{int}})$.

1 7. The method of claim 6, further including the step of:
2 accumulating the reduction error, wherein the accumulated reduction error is used
3 in determining the number of bits to shave from a subsequent portion of
4 the frame.

1 8. The method of claim 6, wherein the number of portions in the frame is N_{portions},
2 wherein the given portion is the Kth out of the N_{portions} to be processed according to steps
3 (e), (f), (g) and (h), and further including the steps of:

4 determining the total compressed content size (C_T) of the frame; and

5 accumulating the reduction error for the preceding (K-1) portions;

6 wherein the number of bits to shave from the given portion is given by

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$$N_{\text{SHAVE}} = S_{\text{INT}} \times \frac{N_s}{C_T} + \frac{E}{N_{\text{portion}} - K + 1}, \text{ where } E \text{ is the accumulated}$$

8 reduction error for the preceding portions.

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9. The method of claim 1, further including the step of:
after step (f) and prior to step (g), re-determining at least one of the statistics of
the given portion, wherein the at least one re-determined statistics about
the given portion is used in step (g).
10. The method of claim 9, wherein the determined statistics include the compressed
content size (Ssize) of the given portion, and the compressed content size is re-determined
after the given portion has been requantized.
11. The method of claim 1, further including the steps of:
determining a requantization parameter for the given portion based at least upon
one of the determined statistics about the given portion.
12. The method of claim 11, wherein the given portion was previously quantized
using a first quantization parameter (Q_1), wherein the requantization parameter (Q_2) is
twice the first quantization parameter, $Q_2 = 2Q_1$.
13. The method of claim 11, wherein the given portion was previously quantized
using a first quantization parameter (Q_1), wherein the requantization parameter (Q_2) is
four times the first quantization parameter, $Q_2 = 4Q_1$.
14. The method of claim 11, wherein the requantization parameter is chosen such that
the compressed content size of the given portion is reduced by approximately 60%
to 70%.
15. The method of claim 11, wherein the requantization parameter is chosen such that
the compressed content size of the given portion is reduced by at least 70%.

1 16. The method of claim 11, wherein the given portion is made up of multiple blocks
2 of previously quantized levels, and step (d) includes determining both the maximum
3 quantization parameter (Q1MAX) used in quantizing the previously quantized levels and
4 the average of the previously quantized levels (Lavg), and wherein Q1MAX and Lavg are
5 used in determining the requantization parameter.

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1 17. The method of claim 11, further including the step of:
2 determining the picture-type of the video frame, wherein the video frame is an
3 MPEG frame, and the group of picture-types consist of I-Picture, P-Picture
4 and B-Picture, and wherein the picture-type of the video frame is used in
5 determining the requantization parameter.

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1 18. The method of claim 1, further including the steps of:
2 prior to step (h), determining a target number (N_{THRESH}) of levels to set to zero by
3 thresholding;
4 determining the number of levels (CNT) beneath a threshold function having a
5 predetermined width and height profile;
6 responsive to the number of levels (CNT) beneath the threshold function being
7 within a predetermined range of the target number (N_{THRESH}), setting the
8 magnitude of the levels beneath the threshold function to zero; and
9 responsive to the number of levels (CNT) beneath the threshold function being
10 outside of the predetermined range of the target number (N_{THRESH}),
11 adjusting the threshold function.

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1 19. The method of claim 18, wherein the step of adjusting further includes the step of:
2 changing the height profile of the threshold function.

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1 20. The method of claim 19, wherein the height profile is increment.

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1 21. The method of claim 19, wherein the height profile is decrement.

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1 22. The method of claim 18, wherein the levels are arranged in order of scan position,
2 and the threshold function extends over a first range of scan positions, and the step of
3 adjusting further includes the step of:

4 shifting the relative location of the threshold function such that the threshold
5 function extends over a second of range of scan positions.

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1 23. The method of claim 22, wherein the smallest scan position included in the first
2 range of scan positions is smaller than the smallest scan position included in the second
3 range of scan positions.

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1 24. The method of claim 22, wherein the smallest scan position included in the first
2 range of scan positions is greater than the smallest scan position included in the second
3 range of scan positions.

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1 25. The method of claim 18, wherein the threshold function extends over a first range
2 of scan positions, and the given portion is made up of multiple blocks of levels, and the
3 step of adjusting further includes the step of:

4 partitioning the blocks of the given portion into a first group and a second group
5 of blocks;

6 associating a second threshold function with the second group, wherein the second
7 threshold function extends over a second range of scan positions;

8 (m) determining the number of levels (CNT1) beneath the first threshold function;

9 (n) determining the number of levels (CNT2) beneath the second threshold
10 function;

11 (o) responsive to the sum of CNT1 and CNT2 being within the predetermined
12 range of the target number (N_{THRESH}), setting the magnitude of the levels
13 beneath the first and second threshold functions to zero;

14 (p) responsive to the sum of CNT1 and CNT2 being outside of the predetermined
15 range of the target number (N_{THRESH}), transferring a predetermined number
16 of blocks from the first group to the second group; and

17 responsive to the sum of CNT1 and CNT2 being outside of the predetermined
18 range of the target number (N_{THRESH}), repeating steps (m), (n), (o), and (p)
19 until the sum of CNT1 and CNT2 is within the predetermined range of the
20 target number (N_{THRESH}).

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1 26. The method of claim 1, wherein the given portion of the frame is a slice of the
2 frame having multiple blocks of levels, and the blocks of levels are thresholded in
3 parallel.

1 27. An apparatus in a network for transcoding a digital stream of compressed frames, the
2 apparatus comprising:

3 a decoder adapted to decompress a video frame having content information and
4 non-content information included therein into the DCT-domain, wherein
5 the content-information carried by the frame is represented as levels in the
6 DCT-domain;

7 a rate controller adapted to receive the video frame, parse the video frame into a
8 plurality of portions, determine a plurality of statistics about a given
9 portion, and determine a target number of bits to shave (N_{shave}) from the
10 given portion;

11 a requantizer adapted to requantize levels of the given portion;

12 a thresholder adapted to threshold the given portion, wherein the rate controller
13 determines whether the given portion should be requantized and whether
14 the given portion should be thresholded based at least in part on at least
15 one of the statistics about the given portion; and

16 an encoder adapted to compress the frame, wherein the compressed size of the
17 frame is approximately the same as a target size.

1 28. The apparatus of claim 27, wherein the plurality of statistics about the given
2 portion include the compressed content size (S_{size}) of the given portion.

1 29. The apparatus of claim 27, wherein the plurality of statistics about the given
2 portion include the average of the quantization parameters used to quantize the levels of
3 the given portion.

1 30. The apparatus of claim 27, wherein the plurality of statistics about the given
2 portion include the maximum quantization parameter used to quantize the levels of the
3 given portion.

31. The apparatus of claim 27, wherein the rate controller determines the initial compressed content size (S_{int}) of the given portion and the final compressed content size (S_{fnl}) of the given portion, and the rate controller calculates the reduction error (e) for the given portion, wherein the reduction error is defined as the difference between the target number of bits to shave and the difference between final and initial compressed content size, $e = N_{\text{shave}} - (S_{\text{fnl}} - S_{\text{int}})$.

32. The apparatus of claim 31, wherein the rate controller accumulates the reduction error, and the accumulated reduction error is used in determining the number of bits to shave from a subsequent portion of the frame.

33. The apparatus of claim 31, wherein the number of portions in the frame is N_{portions} , wherein rate controller processes the plurality of portions sequentially and the given portion is the K^{th} portion out of the N_{portions} portion to be processed, the rate controller further adapted to determine the total compressed content size (C_T) of the frame, and accumulate the reduction error for the preceding (K-1) portions, wherein the number of bits to shave from the given portion is given by $N_{\text{SHAVE}} = S_{\text{INT}} \times \frac{N_s}{C_T} + \frac{E}{N_{\text{portion}} - K + 1}$, where E is the accumulated reduction error for the preceding portions.

34. The apparatus of claim 27, wherein the rate controller re-determines at least one of the statistics of the given portion responsive to requantizing the given portion, wherein the at least one re-determined statistics about the given portion is used to determine whether to threshold the given portion.

35. The method of claim 34, wherein the determined statistics include the compressed content size (S_{size}) of the given portion, and the compressed content size is re-determined after the given portion has been requantized.

36. The method of claim 27, wherein the rate controller is further adapted to determine a requantization parameter for the given portion based at least upon one of the determined statistics about the given portion.

1 37. The method of claim 36, wherein the given portion was previously quantized
2 using a first quantization parameter (Q_1), wherein the requantization parameter (Q_2) is
3 twice the first quantization parameter, $Q_2 = 2Q_1$.

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1 38. The method of claim 36, wherein the given portion was previously quantized
2 using a first quantization parameter (Q_1), wherein the requantization parameter (Q_2) is
3 four times the first quantization parameter, $Q_2 = 4Q_1$.

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1 39. The method of claim 36, wherein the requantization parameter is chosen such that
2 the compressed content size of the given portion is reduced by approximately 60%
3 to 70%.

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1 40. The method of claim 36, wherein the requantization parameter is chosen such that
2 the compressed content size of the given portion is reduced by at least 70%.

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1 41. The method of claim 36, wherein the given portion is made up of multiple blocks
2 of previously quantized levels, and the rate controller determines both the maximum
3 quantization parameter ($Q1MAX$) used in quantizing the previously quantized levels and
4 the average of the previously quantized levels ($Lavg$), and wherein $Q1MAX$ and $Lavg$ are
5 used in determining the requantization parameter.

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1 42. The method of claim 36, wherein the rate controller is further adapted to
2 determine the picture-type of the video frame, wherein the video frame is an MPEG
3 frame, and the group of picture-types consist of I-Picture, P-Picture and B-Picture, and
4 wherein the picture-type of the video frame is used in determining the requantization
5 parameter.

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1 43. The method of claim 27, wherein the rate controller is further adapted to
2 determine a target number (N_{THRESH}) of levels to set to zero by thresholding; wherein the
3 thresholder is adapted to determine the number of levels (CNT) beneath a threshold
4 function having a predetermined width and height profile, responsive to the number of
5 levels (CNT) beneath the threshold function being within a predetermined range of the
6 target number (N_{THRESH}), the thresholder sets the magnitude of the levels beneath the
7 threshold function to zero, and responsive to the number of levels (CNT) beneath the
8 threshold function being outside of the predetermined range of the target number
9 (N_{THRESH}), the thresholder adjusts the threshold function.

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1 44. The method of claim 43, wherein the thresholder adjusts the threshold function by
2 changing the height profile of the threshold function.

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1 45. The method of claim 44, wherein the height profile is increment.

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1 46. The method of claim 44, wherein the height profile is decrement.

1 47. The method of claim 43, wherein the levels are arranged in order of scan position,
2 and the threshold function extends over a first range of scan positions, and the thresholder
3 adjusts the thresholding function by shifting the relative location of the threshold function
4 such that the threshold function extends over a second of range of scan positions.

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1 48. The method of claim 47, wherein the smallest scan position included in the first
2 range of scan positions is smaller than the smallest scan position included in the second
3 range of scan positions.

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1 49. The method of claim 47, wherein the smallest scan position included in the first
2 range of scan positions is greater than the smallest scan position included in the second
3 range of scan positions.

1 50. The method of claim 43, wherein the threshold function extends over a first range
2 of scan positions, and the given portion is made up of multiple blocks of levels, and the
3 thresholder adjusts the thresholding function by the steps of:

4 partitioning the blocks of the given portion into a first group and a second group
5 of blocks;

6 associating a second threshold function with the second group, wherein the second
7 threshold function extends over a second range of scan positions;

8 (a) determining the number of levels (CNT1) beneath the first threshold function;

9 (b) determining the number of levels (CNT2) beneath the second threshold
10 function;

11 (c) responsive to the sum of CNT1 and CNT2 being within the predetermined
12 range of the target number (N_{THRESH}), setting the magnitude of the levels
13 beneath the first and second threshold functions to zero;

14 (d) responsive to the sum of CNT1 and CNT2 being outside of the predetermined
15 range of the target number (N_{THRESH}), transferring a predetermined number
16 of blocks from the first group to the second group; and

17 responsive to the sum of CNT1 and CNT2 being outside of the predetermined
18 range of the target number (N_{THRESH}), repeating steps (a), (b), (c), and (d)
19 until the sum of CNT1 and CNT2 is within the predetermined range of the
20 target number (N_{THRESH}).

1 51. The method of claim 27, wherein the given portion of the frame is a slice of the
2 frame having multiple blocks of levels, and the blocks of levels are thresholded by the
3 thresholder in parallel.